Space Weather Technical Forecast

Issued on Monday, 04 December 2023 at 13:22 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1-G2 (Minor-Moderate geomagnetic storms) likely day 1 and 2 (04-05 Dec). Chance of isolated M-Class flares (R1-R2 Blackouts) days 1 and 2 (04-05 Dec).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity is Low with the largest flare of the past 24 hours a C8.1 flare at 04/0126 UTC from AR3511. There are nine sunspot regions on the disc. AR3500, is now approaching the southwest limb, and after a period of activity when it was centre disk, has been largely inactive recently and continues a slowly decay. AR3510 and AR3511 in the southeastern quadrant approaching centre disk continue to emerge, with the latter developing a delta group in it's central portion, it was also responsible for the aforementioned high-level C-class flare early on 04 Dec. The remaining regions on the visible disc are mature and stable.

Despite a number of CME signatures evidenced in coronagraph imagery during the past 24 hours, none are considered Earth-directed. A recent filament that erupted from near AR3511 around 03/07000 UTC has given a CME, however, further analysis of solar imagery is required to confirm the direction and size.

Solar Wind / Geomagnetic Activity: Solar wind parameters have been indicative of the steady arrival of a coronal hole high-speed stream, speculated to be the early arrival of CH76/-. Solar wind speeds, as observed by DSCOVR at L1, rose from slightly elevated to elevated levels, from around 400-550 km/s. Density was largely between average and above average levels, with a peak of 31pppc at 03/1604 UTC. The Interplanetary Magnetic Field (IMF), Bt, was initially weak before rising to moderate levels after 04/0500 UTC, peaking at 12nT at 04/0844 UTC. The north-south component of the IMF (Bz), was largely positive, fluctuating between +8/09nT. Phi angle has been negative (towards the Sun) throughout. Resultant Geomagnetic activity was Quiet to Unsettled (Kp 1-3).

Energetic Particles / Solar Radiation: GOES16 high energy (greater than 10MeV) proton flux remained at Background levels. GOES16 high energy (greater than 2MeV) electron flux has been Background. The associated 24-hour fluence has remained below the Active threshold (1e8 integrated pfu) with a steady trend. The observation at 03/0000 UTC was 1.33e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low with a chance for isolated M-flares (R1-R2 Blackouts) on days 1-2 (04-05 Dec), reducing to a slight chance on days 3-4 (06-07 Dec).

Solar Wind / Geomagnetic Activity: A CME that left the sun on 01 Dec is expected to give a glancing blow at Earth late day 1 (04 Dec) or early day 2 (05 Dec). No further CMEs are currently thought to be Earth-directed. Solar winds have increased to Elevated levels. Solar wind parameters suggest this may be the early onset of the HSS from CH76/-. Strong winds of around 600-650km/s are expected at peak. This increase in speed from Elevated levels is forecast to take place during days 1 and 2 (04 and 05 Dec). Strong or Elevated speeds may persist through into day 3 (06 Dec) before slowly easing to Slightly Elevated levels by day 4 (07 Dec).

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Met Office Space Weather Technical Forecast

Geomagnetic activity is expected to be Quiet to Unsettled, then forecast to increase to G1-G2/Minor-Moderate Storm (Kp 5-6) levels later day 1 (04 Dec) and early day 2 (05 Dec). Following peak geomagnetic activity, indices should fall to Unsettled to Active by the end of day 2 (05 Dec), before becoming Quiet to Unsettled from day 3 (06 Dec) onwards.

Energetic Particles / Solar Radiation: GOES16 high energy proton flux is forecast to remain at background levels with no Solar Radiation Storms expected.

Electron flux is at background. Continued suppression is expected as geomagnetic activity increases within the HSS from CH76/-. An increase to High levels is likely by day 3 and 4 (06-07 Dec) as the electron belts relax back towards ambient positions. The associated 24 hour electron fluence is expected to remain below the Active (1e8 integrated pfu) threshold. However, a rising trend is likely from days 3 and 4 (06-07 Dec) with a chance of exceeding the Active threshold on day 4.

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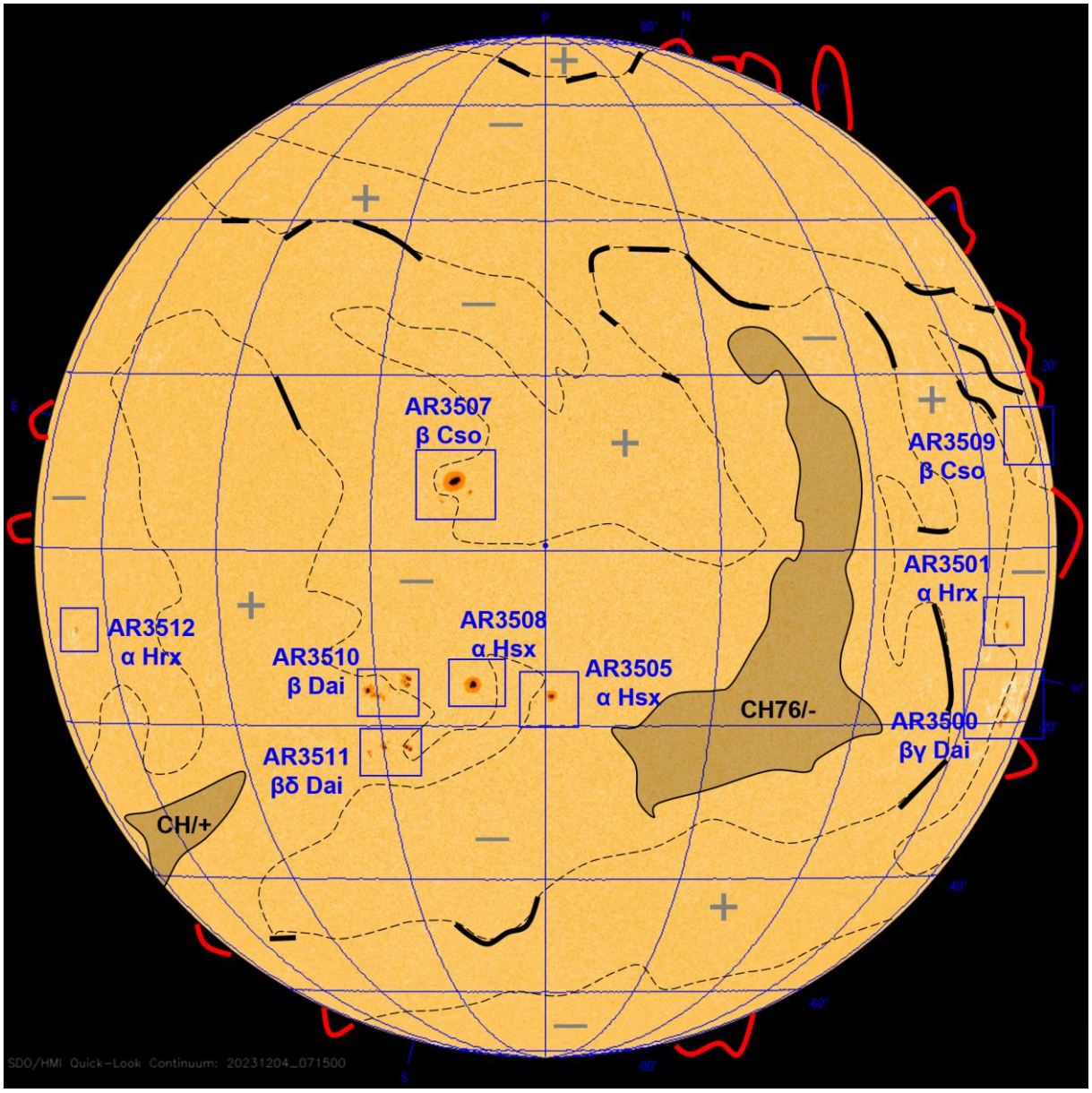
Figure 1. Solar Analysis Valid 04/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A CME that left the sun in association with the M1.1 flare from AR3500 at 01/2120 UTC has been analysed and modelled. Although the majority of the ejecta is forecast to pass ahead of and below Earth orbit, there is a chance of a glancing blow late day 1 (04 Dec) or early day 2 (05 Dec). No further CMEs are currently thought to be Earth-directed.

Solar winds have increased to Elevated levels. Solar wind parameters suggest this may be the early onset of the HSS from CH76/-. This coronal hole is a persistent feature and similar in size and position to the previous rotation. However during the previous solar rotation a CME arrival masked the initial influence of the coronal hole. Despite this, Strong winds of around 600-650km/s are expected at peak, though with slightly lower than average confidence in the highest speeds from this feature. This increase in speed from Elevated levels is forecast to take place during days 1 and 2 (04 and 05 Dec). Strong or Elevated speeds may persist through into day 3 (06 Dec) before slowly easing to Slightly Elevated levels by day 4 (07 Dec).

Geomagnetic activity is expected to be Quiet to Unsettled, then forecast to increase to G1-G2/Minor-Moderate Storm (Kp 5-6) levels late day 1 (04 Dec) and early day 2 (05 Dec). Following peak geomagnetic activity, indices should fall to Unsettled to Active by the end of day 2 (05 Dec), before becoming Quiet to Unsettled from day 3 (06 Dec) onwards.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	60	60	5	1
Strong	G3	No	5	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
02/0440	Partial	M1.0 Flare AR3500	SW	585 km/s	04/1800 UTC	Chance of glancing blow with limited shock

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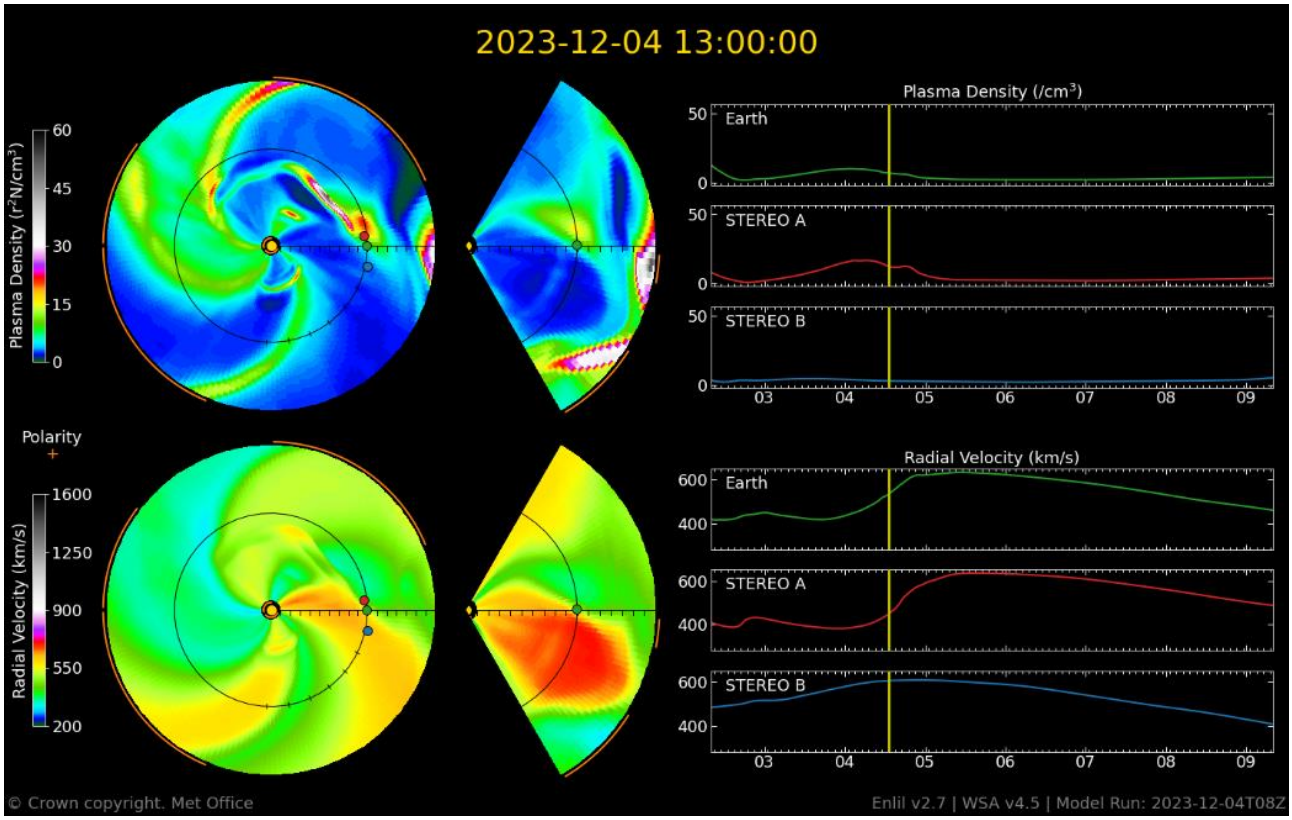
Figure 2: MOSWOC ENLIL



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Radio Blackouts - X-Ray Flares:

The largest flare of the past 24 hours was a C8.1 flare at 04/0126 UTC from AR3511.

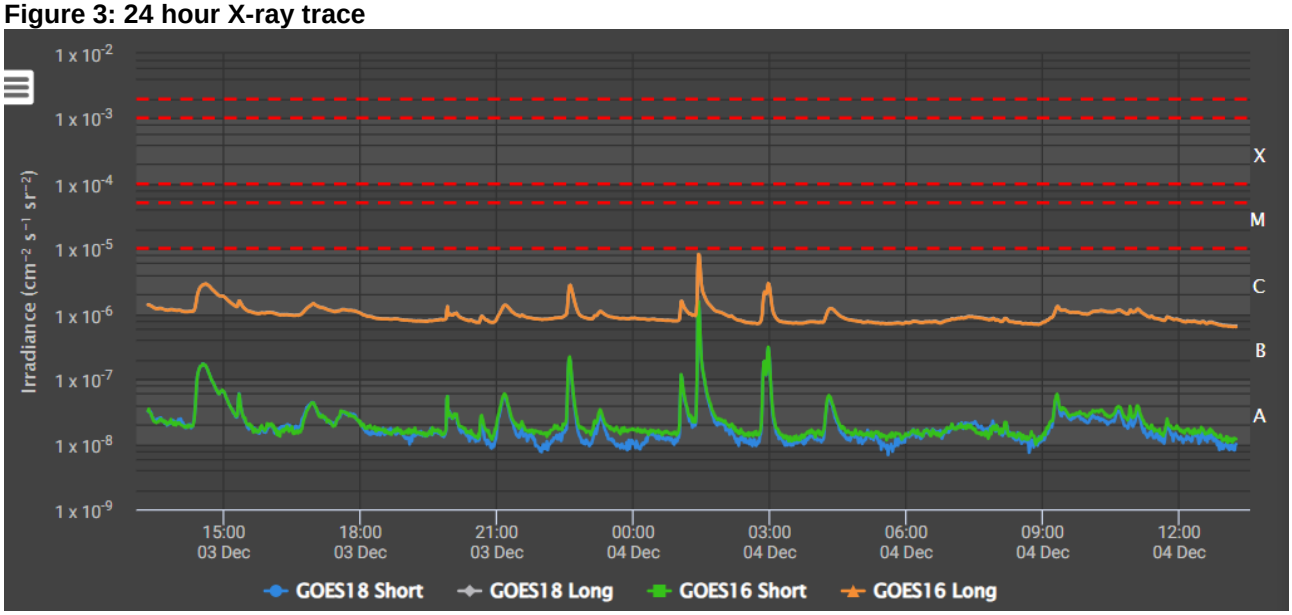
There are nine sunspot regions on the disc. AR3500, is now approaching the southwest limb, and after a period of activity when it was centre disk, has been largely inactive recently and continues a slowly decay. AR3510 and AR3511 in the southeastern quadrant approaching centre disk continue to emerge, with the latter developing a delta group in it's central portion, it was also responsible for a high-level C-class flare early on 04 Dec. AR3507 appears similar to before, containing a large, mature leader spot and several smaller spots of mixed polarity to the south. The remaining regions on the visible disc are mature and stable.

A number of sunspots in the western hemisphere, including AR3500, are due to rotate over the western limb in the forecast period. No significant returning or new regions are expected to rotate over the eastern horizon in the coming days, so the likelihood of significant flares reduces overall in the absence of any notable developments on the visible disc.

Solar activity is expected to be Low with a chance for isolated M-flares (R1-R2 Blackouts) on days 1-2 (04-05 Dec), reducing to a slight chance on days 3-4 (06-07 Dec).

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	30	15	15
Very Active	R3 to R5 X Class	No	5	3	1	1

Figure 3: 24 hour X-ray trace



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at Background and expected to remain at this level. There is a reducing very slight chance of S1/Minor Storm conditions being reached on days 1-2 (04-05 Dec) should any significant flares occur, mainly from AR3500 in the southwest, though the risk diminishes by day 3 (06 Dec) as the region rotates off the visible disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	5	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

Electron flux is at background levels with the Van Allen belts still suppressed following recent enhanced geomagnetic activity. Continued suppression is expected as geomagnetic activity increases within the HSS from CH76/-. An increase to High levels is likely by day 3 and 4 (06-07 Dec) as the electron belts relax back towards ambient positions.

The associated 24 hour electron fluence is expected to remain below the Active (1e8 integrated pfu) threshold. However, a rising trend is likely from days 3 and 4 (06-07 Dec) with a chance of exceeding the Active threshold on day 4. REFM is considered to be providing reasonable guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	5	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: MOSWOC REFM integrated flux/fluence forecast/observations/persistence

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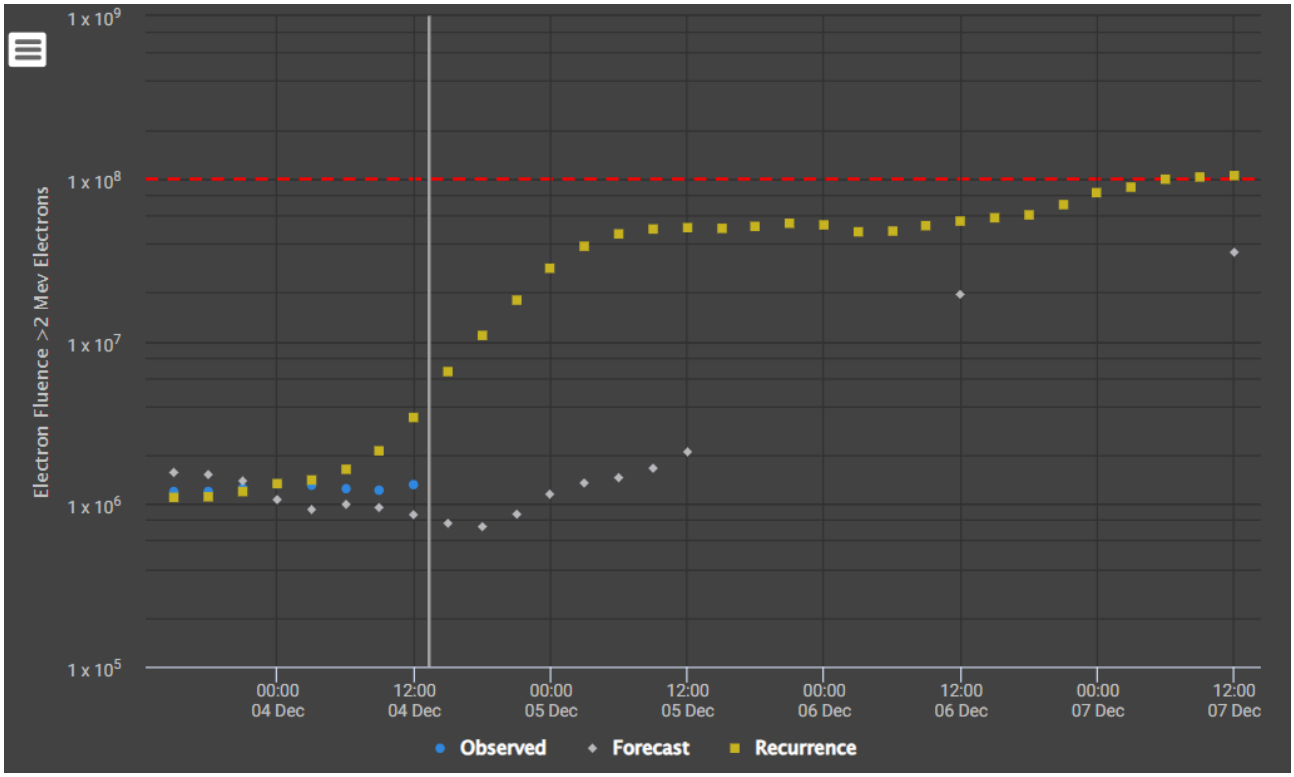

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